ABC of preterm birth

Feeding the preterm infant

This is the eighth in a series of 12 articles

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Providing appropriate nutrition for growth and development is a cornerstone of the care of preterm infants. Early postnatal nutrition during this critical period of brain growth may have a substantial impact on clinically important outcomes, including long term neurodevelopment.

Preterm infants, especially those who have been growth restricted in utero, have fewer nutrient reserves at birth than term infants. Additionally, preterm infants are subject to physiological and metabolic stresses that can affect their nutritional needs, such as respiratory distress or infection. An international consensus group has recommended nutritional requirements for preterm infants. These recommendations are based on data from intrauterine growth and nutrient balance studies and assume that the optimal rate of postnatal growth for preterm infants should be similar to that of normal fetuses of the same postconception age. In practice, however, these target levels of nutrient input are not always achieved and this may result in important nutritional deficits.

Nutritional requirements for preterm infants*

- Energy—110-20 kcal/kg/day
- Protein—3-3.8 g/kg/day
- Fat—4.5-6.8 g/kg/day
- Calcium—120-230 mg/kg/day
- Phosphorus—60-140 mg/kg/day

*International consensus group recommendations

Enteral feeding

Well infants of gestational age > 34 weeks are usually able to coordinate sucking, swallowing, and breathing, and so establish breast or bottle feeding. In less mature infants, oral feeding may not be safe or possible because of neurological immaturity or respiratory compromise. In these infants milk can be given as a continuous infusion or as an intermittent bolus through a fine feeding catheter passed via the nose or the mouth to the stomach.

Necrotising enterocolitis

A major concern with the introduction of enteral feeds (especially to very preterm, growth restricted, or sick infants) is that the additional physiological strain on the immature gastrointestinal tract may predispose to the development of necrotising enterocolitis. The risk of necrotising enterocolitis is inversely related to gestational age and birth weight. The incidence is 5-10% in very low birth weight infants. The mortality rate is reported consistently as greater than 20%. Long term morbidity may include substantial neurodevelopmental problems, the consequence of undernutrition and associated infection during a vulnerable period of growth and development.

Most preterm infants who develop necrotising enterocolitis have received enteral feeds. At present, however, limited evidence exists that the way that we feed infants who are at risk affects the incidence of necrotising enterocolitis. Large randomised controlled trials are needed to determine whether strategies, such as delaying the introduction of milk feeds or delivering only minimal enteral nutrition, influence clinically

Infants with intrauterine growth restriction lack subcutaneous fat and other nutrient stores

Infants can be fed using a gastric tube if they are unable to breast or bottle feed

Preterm infant with necrotising enterocolitis—a syndrome of acute intestinal necrosis of unknown aetiology

Presenting clinical features of necrotising enterocolitis

- Abdominal distension
- Abdominal tenderness or rigidity
- Lethargy, hypotonia, or apnoea
- Hepatic portal gas on abdominal x ray
- Intramural gas (pneumatosis intestinalis) on abdominal x ray
- Intestinal perforation
- Blood or mucosa in stool

important outcomes for preterm infants. Apart from assessing the impact of feeding strategies on short term outcomes, such as growth, and the risk of necrotising enterocolitis, trials should also determine how various enteral feeding strategies affect mortality and long term neurodevelopment.

Which milk?

Human breast milk is the recommended form of enteral nutrition for preterm infants. The milk could be from the infant's mother or expressed milk from donor mothers, who are usually mothers who have delivered term infants. The nutrient content of expressed breast milk varies depending on the stage of lactation at which it is collected. Milk expressed from a donor's lactating breast has a higher calorie and protein content than that collected from the opposite breast (drip breast milk).

Human breast milk, particularly donated drip breast milk, may not consistently provide all of the nutrient requirements of preterm infants. Multinutrient fortifiers are available to add to human milk to achieve these targets. Fortification of human milk with calcium and phosphate may improve bone mineral content. Protein and energy supplementation of human milk increases the rate of weight gain and head growth, at least in the short term. Long term follow up studies are needed to determine if nutrient fortification of human milk improves neurodevelopmental outcomes for preterm infants.

Human breast milk has non-nutrient advantages for preterm infants, primarily through the delivery of immunoprotective and growth factors to the immature gut mucosa. Some evidence exists that preterm infants who receive human breast milk rather than formula milk have a lower incidence of feed intolerance and gastrointestinal upset, and a lower incidence of necrotising enterocolitis.

Supporting mothers to express breast milk

Mothers may be very anxious after preterm delivery, especially if their infant needs intensive care. Although feeding might not be seen as an immediate concern, mothers should be aware that providing breast milk is one of the most important parts of their infant's care. In developing countries, supporting mothers to provide expressed breast milk may be the most important intervention available for preterm infants. Feeding with expressed human milk reduces the risk of serious infection, which is a major cause of neonatal morbidity and mortality in preterm infants in developing countries.

Various initiatives may help mothers who are expressing breast milk:

- Early discussion of breast feeding
- Written information
- Frequent expression
- Simultaneous expression of both breasts
- Breast massage
- Use of electric pump
- Skin to skin contact
- Sucking from as early as 32 weeks after conception
- Cup feeding
- Continued support and education.

The initiation of skin to skin contact between mother and infant (although not always possible for lengthy periods of time with extremely preterm infants) can help with bonding, milk production, and the subsequent establishment of breast feeding. Milk can be delivered via a gastric tube or by cup feeding while the infant is learning to suck at the breast. Bottle feeding should be avoided as it may interfere with the establishment of breast feeding.

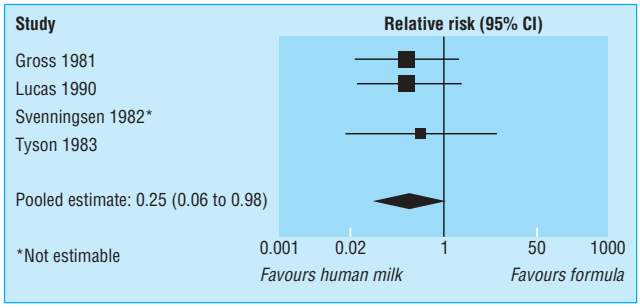
Minimal enteral nutrition—main points

- Also called trophic feeding, gut priming, hypocaloric feeding
- Feeds nutritionally insignificant volumes of enteral milk (0.5-1.0 ml/hour)
- Aims to stimulate postnatal development of gastrointestinal system
- Used in parallel with total parenteral nutrition
- Enteral feeds' volume increases after prespecified interval, typically 7-14 days

Typical nutritional contents of human expressed breast milk (per 100 ml)*

	Milk expressed from lactating breast	Drip milk expressed from opposite breast
Energy (kcal)	73	54
Protein (g)	2.7	1.3
Fat (g)	3.0	2.2
Calcium (mg)	29	28
Phosphate (mg)	15	14

*Data from Rennie J, Robertson NRC. *A manual of neonatal intensive care*, 4th ed, London: Arnold, 2002



Relative risk of confirmed necrotising enterocolitis with human milk versus formula. Adapted from McGuire W, Anthony MY. *Arch Dis Child* 2003;88:11-14

Human breast milk can be expressed from the infant's mother or from a donor mother

Donor milk banking

Use of donor milk for preterm infants has declined over the past 20 years. This fall is caused by concerns about the nutritional adequacy of donor breast milk, the resources needed to pasteurise and store donated milk, and the cost and feasibility of screening donors for transmissible infections, such as the human immunodeficiency virus. In several countries, efforts have been made to re-establish donor milk banks that were closed in the 1980s. Economic studies show that the costs of this service may be balanced by the potential health gains associated with feeding with human milk—for example, a shorter stay in hospital.

Formula milks

Despite optimal maternal support, expressed breast milk may not always be available. As an alternative, preterm infants may be fed with a variety of artificial formula milks, mainly modified cow's milk. Broadly, these may be "term" formulae (based on the composition of mature breast milk), or calorie, protein, and mineral enriched "preterm" formulae (tailored to support intrauterine nutrient accretion rates). Some evidence exists that feeding very preterm infants with preterm formula milk increases the rate of weight gain and head growth, at least in the short term, and improves some neurodevelopmental outcomes. No evidence exists that feeding preterm infants with formula milk supplemented with long chain polyunsaturated fatty acids is beneficial.

Parenteral nutrition

Very preterm infants, who often have relatively delayed gastric emptying and intestinal peristalsis, may be slow to tolerate the introduction of gastric tube feeds. These infants may need intravenous nutrition while enteral nutrition is being established or when enteral nutrition is not possible—for example, because of respiratory instability, feed intolerance, or serious gastrointestinal disease.

Total parenteral nutrition consists of a glucose and amino acid solution with electrolytes, minerals, and vitamins, plus fat as the principal non-protein energy source. The solutions are usually prepared in a specialist pharmacy to minimise the risk of microbial contamination. Bloodstream infection is the most common important complication of parenteral nutrition use. Delivery of the solution via a central venous catheter rather than a peripheral catheter is not associated with a higher risk of infection. Extravasation injury is a major concern when parenteral nutrition is given via a peripheral cannula. Subcutaneous infiltration of a hypertonic and irritant solution can cause local skin ulceration, secondary infection, and scarring.

Nutrition after hospital discharge

Most preterm infants, and especially very preterm infants, have an accumulated nutritional deficit when they are discharged from hospital. Iron and vitamin supplementation is necessary until infants are at least six months old, especially if they are fed on breast milk only. Protein and energy enriched formula milk may improve catch-up growth, at least in the short term. This may be of particular importance for infants with additional metabolic requirements, such as those caused by chronic lung disease. Further research is needed to determine if breast milk should be fortified after the infant is discharged.

Skin to skin care promotes bonding and milk production (left). The infant can be cup fed (right) until breast feeding is established

Typical content of nutrient enriched preterm formula milk compared with standard term formula (per 100 ml)*

	Preterm formula	Term formula
Energy (kcal)	80	67
Protein (g)	2.0	1.4
Fat (g)	4.5	3.6
Calcium (mg)	77-110	39-66
Phosphate (mg)	33-63	27-42

*Data from Rennie J, Robertson NRC. *A manual of neonatal intensive care*, 4th ed, London: Arnold, 2002

Complications of total parenteral nutrition

Catheter related complications
- Bacteraemia (staphylococcal)
- Invasive fungal infection
- Thrombosis
- Extravasation injuries
- Cardiac tamponade

Metabolic complications
- Cholestatic jaundice
- Hyperglycaemia or glycosuria
- Vitamin deficiencies or excesses
- Hyperammonaemia

Extravasation injury may occur when a peripheral cannula is used to deliver the parenteral nutrition solution

Conclusion

The nutritional management of preterm infants may have a major impact on growth and development. Various feeding strategies are available, including the use of expressed maternal milk, donor human milk, breast milk fortifiers, adapted formula milks, and total parenteral nutrition. A lack of robust evidence exists to guide practice for many of these interventions. Large, pragmatic randomised controlled trials are needed to assess the effects of a number of these feeding strategies on clinically important outcomes for preterm infants.

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The photographs showing a woman expressing breast milk, skin to skin contact, and cup feeding are courtesy of the Health Promotion Agency for Northern Ireland.

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Further reading

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A memorable patient

With a pinch of salt

Some years ago I was asked by a family doctor to visit a 69 year old man at home to take a history and carry out a physical examination and to perform an electrocardiograph to rule out myocardial infarction after an episode of chest pain the previous day.

The patient said that 50 years previously, he had been told that he had Addison's disease, but when I asked him about drugs he looked at me blankly and said that he had never heard of cortisol or steroid replacement therapy: "No, doctor, in those days there was no treatment for the condition, and I was told that my only chance of staying alive was to take a whole packet of salt a day."

To confirm this, he led me through to his kitchen, where he opened a cupboard to reveal several large cardboard boxes containing packets of salt, each of which weighed about a pound. "For the past 50 years," he said, "I've taken one of these every day."

I was now faced with an ethical dilemma. The patient had clearly not had a myocardial infarction. His chest pain was worse with movement and pressure over the left upper chest and was obviously of musculoskeletal origin. Apart from this and Addison's disease, which seemed to be well controlled with a packet of salt a day, he was a well man. Should I interfere and offer him treatment with cortisol and fludrocortisone, or should I leave well alone? Hippocrates' words—"First do no harm"—echoed in my mind.

In the end I decided to share my dilemma with the patient, and we agreed that I would be guided by him after he had had time to reflect on the matter. To this end I arranged to see him in my outpatient clinic three weeks later with the results of the appropriate blood tests.

On the appointed day he told me that he had decided to try the modern treatment. I gave him a prescription, and we agreed a policy for tailing off the salt over a period of about 10 days.

When I next saw him, three weeks later, I didn't recognise him, he looked so different. His face was fuller and his complexion brighter, and when I asked him how he felt he said, "I feel splendid. You know, doctor, I now realise that for 50 years I haven't felt quite well."

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We welcome articles up to 600 words on topics such as *A memorable patient, A paper that changed my practice, My most unfortunate mistake,* or any other piece conveying instruction, pathos, or humour. Please submit the article on http://submit.bmj.com Permission is needed from the patient or a relative if an identifiable patient is referred to. We also welcome contributions for "Endpieces," consisting of quotations of up to 80 words (but most are considerably shorter) from any source, ancient or modern, which have appealed to the reader.